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A Discussion of Methods for Determining the Availability of Phosphoric Acid in Thomas Phosphate Powder

(Basic Slag Phosphate)

WITH A COMPLETE TRANSCRIPT OF WAGNER'S METHOD

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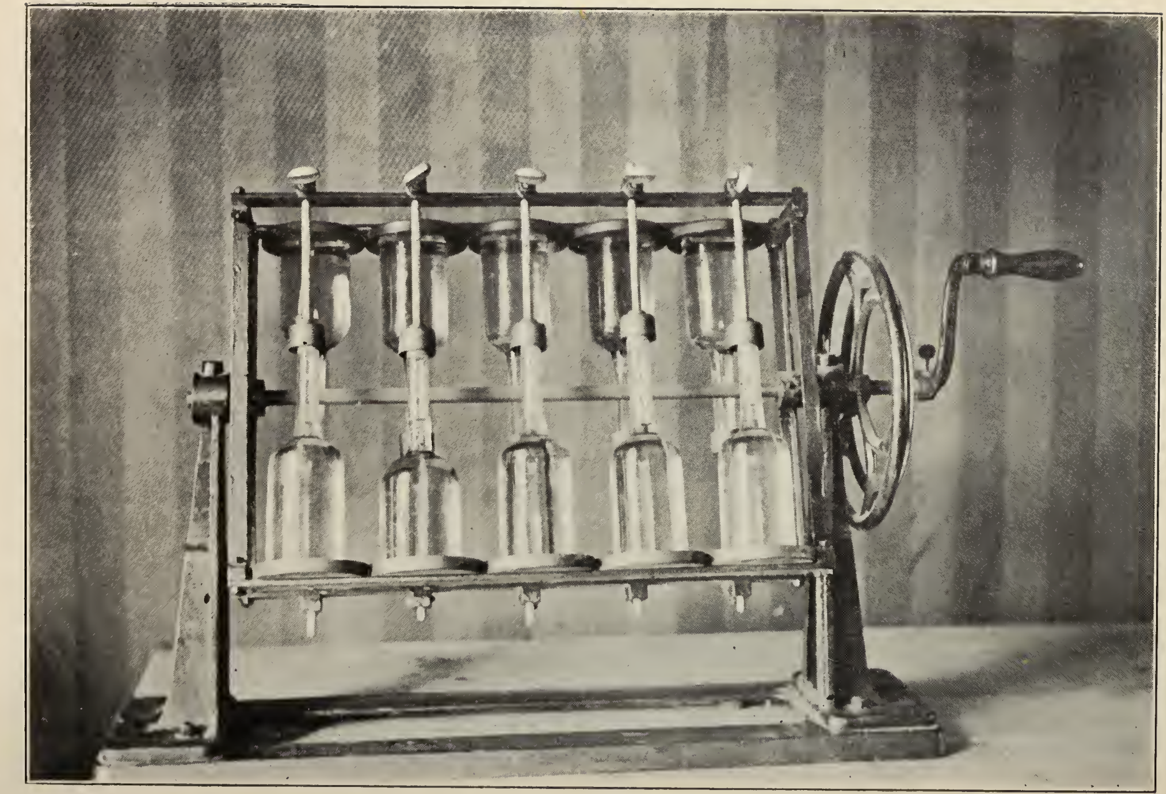

Rotary shaking apparatus used in analysis of Basic Phosphatic Slags according to Wagner's method.

A DISCUSSION OF METHODS FOR DETERMINING THE AVAILABILITY OF THE PHOSPHORIC ACID IN THOMAS PHOSPHATE POWDER

(Basic Slag Phosphate.)

By George D. Leavens, B. S.

INTRODUCTION.

THOMAS PHOSPHATE POWDER (Basic Slag Phosphate), has become, during the past few years, one of the world's most important sources of Phosphoric Acid, its contents of phosphorus representing about half of the world's agricultural consumption of this element in the form of superphosphate of lime. Not only is it used in large quantities in England and on the Continent of Europe, but the exports from Germany alone now amount to millions of tons annually.

Within the last four or five years THOMAS PHOSPHATE POWDER (Basic Slag Phosphate), has been imported into the United States in increasing quantities, it being largely used at the present time in California, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, Ohio, South Carolina, Virginia and Florida.

It is especially effective on acid soils (which are far more widely prevalent in this country than is generally supposed), and gives strikingly favorable results on alfalfa, clover, and other legumes, timothy (herds' grass), cabbages, turnips and all members of the cabbage family, beets and all members of the beet family, corn, wheat and other cereals, and on fruits, particularly apples, peaches, grapes, oranges, lemons, grape-fruit, and pineapples.

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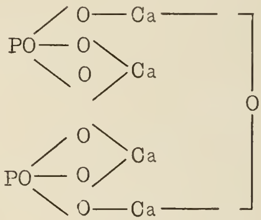
COMPOSITION OF THOMAS PHOSPHATE POWDER.

(Basic Slag Phosphate.)

The Phosphoric Acid in THOMAS PHOSPHATE POWDER is present as tetra-calcium phosphate ($Ca_4 P_2 O_9$). Graphically, this formula may be expressed thus:



The process of the manufacture of THOMAS PHOSPHATE POWDER (Basic Slag Phosphate), is now so generally familiar that it need only be said in passing that it is produced during the manufacture of steel by the Basic Bessemer process, introduced by Thomas & Gilchrist about 1878 or 1879. By this process (which consists in the introduction of a Dolomitic lining for the Bessemer converter and the use of a certain quantity of freshly burned lime), the objectionable phosphorus in the iron ore is combined with these basic materials after the phosphorus has been oxidized to Phosphoric Acid. It is generally considered that the tetra-calcium phosphate formed during this process, is produced during the latter part of the "blow" of the converter, or during what is called the "after-blow."

By means of this process it is possible to make excellent grades of steel from ores that otherwise would be useless on account of their high content of phosphorus.

The following table shows approximately the various changes that take place during the Thomas-Gilchrist process*:

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* Ingle's Manual of Agricultural Chemistry.

	Original pig-iron.	After 12 min.	After 14 min. End of ordinary blow.	After 16½ min. end of after blow.	Steel.
Carbon	3.57%	0.88%	0.07%	trace	0.124%
Silicon	1.70	0.01	trace	nil	0.030
Phosphorus.	1.57	1.42	1.22	0.08%	0.220
Manganese .	0.71	0.27	0.12	trace	0.270
Sulphur ...	0.06	0.05	0.05	0.05	0.040

The table below shows the changes that take place in the Slag itself during the process*:

Phosphorus

	Time from commencement of the blow.				Slag at the end of the process.
	6 min.	12 min.	14½ min.	16½ min.	
Silicon	42.60%	35.60%	33.00%	16.60%	18.60%
Phosphorus pentoxide ..	0.15	2.61	5.66	16.03	13.87
Iron	2.00	4.80	6.15	11.35	7.10

From this it will be seen that the formation of the phosphorus pentoxide takes place during the latter part of the process. The following analysis of a sample of Basic Slag gives an approximate idea of its composition†:

	%
Lime	45.04
Magnesia	6.42
Alumina	1.50
Ferrous oxide	2.10
Ferric oxide	15.42
Manganous oxide	3.50
Vanadious oxide	1.35
Silica	5.80
Sulphur	0.32
Calcium	0.40
Phosphorus pentoxide	18.10
	99.95

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* Ingle's Manual of Agricultural Chemistry.

† Ingle's Manual of Agricultural Chemistry.

This particular analysis appears to have been made on a sample relatively low in Phosphoric Acid. More recent analyses by Wagner, given later, show a much closer approximation of the Phosphoric Acid content of the material as it is being produced at the present time.

AVAILABILITY OF THE PHOSPHORIC ACID IN THOMAS PHOSPHATE POWDER AS SHOWN BY FIELD EXPERIMENTS.

Carefully conducted field experiments have shown that the Phosphoric Acid in the form of tetra-calcium phosphate in THOMAS PHOSPHATE POWDER possesses a much higher degree of availability than is indicated by results obtained from treating the material according to the present official method, in which a neutral solution of Ammonium Citrate is used as a solvent.

Some of the most careful work in this direction has been done by **Wheeler**, at the **Rhode Island Station**, results reported in Bulletins 114 and 118, **"A Test of Nine Phosphates with Different Plants"** being of especial interest. In examining the following tables, which are taken from these Bulletins, it should be borne in mind that all plots have been manured alike with an excess of Nitrogen and Potash, so that the comparison of results may rest solely upon the Phosphoric Acid. The plan of having certain plots limed and other unlimed, also helps to throw some light on whether the benefit derived from any one of the materials is due more especially to the Lime or to the Phosphoric Acid.

AGRICULTURAL AVAILABILITY.

TABLE SHOWING THE YIELDS OF OATS, CUT AND WEIGHED GREEN (POUNDS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	76	52	49
Dissolved bone	53	82	54	59
Acid phosphate	55	65	56	44
Fine ground bone	57	71	58	67
BASIC SLAG MEAL.	59	78	60	76
Floats	61	59	62	55
Redondite (raw)	63	38	64	37
Redondite (roasted) . .	65	70	66	36
No phosphate	67	47	68	19
Double superphosphate	69	74	70	38

TABLE SHOWING THE YIELDS OF ENGLISH OR FLAT TURNIP (POUNDS OF ROOTS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	163	52	162
Dissolved bone	53	177	54	182
Acid phosphate	55	115	56	93
Fine ground bone	57	187	58	161
BASIC SLAG MEAL.	59	192	60	151
Floats	61	121	62	49
Redondite (raw)	63	15	64	3
Redondite (roasted) . .	65	125	66	30
No phosphate	67	9	68	0
Double superphosphate	69	146	70	8

AGRICULTURAL AVAILABILITY

TABLE SHOWING THE YIELDS OF GIANT SUMMER SQUASH (POUNDS).

TOTALS OF THE PICKINGS, MADE ON AUG. 6, 12, 16, 24, AND SEPT. 3.

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	65	52	87
Dissolved bone	53	50	54	60
Acid phosphate	55	74	56	72
Fine ground bone	57	53	58	86
BASIC SLAG MEAL.	59	52	60	85
Floats	61	82	62	69
Redondite (raw)	63	34	64	13
Redondite (roasted) . .	65	70	66	30
No phosphate	67	57	68	4
Double superphosphate	69	46	70	6

TABLE SHOWING THE YIELDS OF CRIMSON CLOVER WHEN CUT AND WEIGHED GREEN (POUNDS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	91	52	106
Dissolved bone	53	109	54	83
Acid phosphate	55	79	56	91
Fine ground bone	57	76	58	112
BASIC SLAG MEAL.	59	82	60	107
Floats	61	90	62	83
Redondite (raw)	63	64	64	111
Redondite (roasted) . .	65	81	66	79
No phosphate	67	75	68	50
Double superphosphate	69	111	70	*32

* "Whether this poor result was due to excessive acidity of this plat induced by the double superphosphate, or to other causes, has not yet been definitely determined." Bulletin 114, R. I. Station.

AGRICULTURAL AVAILABILITY

TABLE SHOWING THE YIELDS OF JAPANESE MILLET (PANICUM CRUS-GALLI) CUT AND WEIGHED GREEN (POUNDS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	220	52	168
Dissolved bone	53	244	54	200
Acid phosphate	55	234	56	213
Fine ground bone	57	245	58	244
BASIC SLAG MEAL.	59	240	60	235
Floats	61	191	62	239
Redondite (raw)	63	130	64	173
Redondite (roasted) . .	65	233	66	199
No phosphate	67	145	68	118
Double superphosphate	69	230	70	146

TABLE SHOWING THE YIELDS OF ECLIPSE TABLE BEETS (POUNDS OF ROOTS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	134	52	1
Dissolved bone	53	136	54	62
Acid phosphate	55	29	56	4
Fine ground bone	57	146	58	56
BASIC SLAG MEAL.	59	189	60	61
Floats	61	7	62	0
Redondite (raw)	63	1	64	0
Redondite (roasted) . .	65	26	66	0
No phosphate	67	2	68	0
Double superphosphate	69	86	70	0

AGRICULTURAL AVAILABILITY

TABLE SHOWING THE YIELDS OF GOLDEN MILLET, CUT AND WEIGHED GREEN (POUNDS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black ..	51	210	52	147
Dissolved bone	53	215	54	214
Acid phosphate	55	214	56	204
Fine ground bone	57	198	58	211
BASIC SLAG MEAL.	59	214	60	190
Floats	61	187	62	202
Redondite (raw)	63	154	64	165
Redondite (roasted) ..	65	199	66	185
No phosphate	67	175	68	94
Double superphosphate	69	203	70	169

TABLE SHOWING THE YIELD OF WHITE-PODDED ADZUKI BEAN (PHASEOLUS MUNGO, VAR.), HARVESTED AND WEIGHED GREEN (POUNDS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black ..	51	143	52	69
Dissolved bone	53	163	54	151
Acid phosphate	55	160	56	150
Fine ground bone	57	176	58	149
BASIC SLAG MEAL.	59	175	60	133
Floats	61	134	62	136
Redondite (raw)	63	116	64	96
Redondite (roasted) ..	65	151	66	86
No phosphate	67	113	68	66
Double superphosphate	69	160	70	62

AGRICULTURAL AVAILABILITY

TABLE SHOWING THE YIELDS OF CABBAGE (VAR. "ALL SEASONS"). POUNDS OF TRIMMED HEADS.

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	115	52	149
Dissolved bone	53	153	54	142
Acid phosphate	55	56	56	48
Fine ground bone	57	173	58	162
BASIC SLAG MEAL.	59	213	60	150
Floats	61	107	62	39
Redondite (raw)	63	4	64	1
Redondite (roasted) . .	65	89	66	1
No phosphate	67	8	68	0
Double superphosphate	69	118	70	0

TABLE SHOWING THE YIELDS OF THE MEDIUM GREEN SOY BEAN, CUT AND WEIGHED GREEN (POUNDS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	170	52	122
Dissolved bone	53	160	54	126
Acid phosphate	55	160	56	126
Fine ground bone	57	161	58	129
BASIC SLAG MEAL.	59	178	60	152
Floats	61	141	62	143
Redondite (raw)	63	99	64	110
Redondite (roasted) . .	65	140	66	109
No phosphate	67	102	68	75
Double superphosphate.	69	113	70	102

AGRICULTURAL AVAILABILITY

TABLE SHOWING THE KINDS OF PHOSPHATES USED AND THE YIELDS IN BUSHELS PER ACRE OF SHELLED SOY BEANS IN 1902.

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black .	51	27.5	52	23.3
Dissolved bone	53	29.3	54	26.8
Dissolved phosphate rock	55	27.7	56	25.3
Fine ground bone	57	29.3	58	27.5
BASIC SLAG MEAL.	59	29.8	60	27.3
Floats	61	26.5	62	23.6
Redondite (raw)	63	17.2	64	16.0
Redondite (roasted) ..	65	24.6	66	19.1
No phosphate	67	16.7	68	14.2
Double superphosphate	69	25.3	70	19.7

TABLE SHOWING YIELDS OF GREEN PEAS IN THE POD (POUNDS)

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black .	51	29	52	15
Dissolved bone	53	32	54	20
Acid phosphate	55	27	56	19
Fine ground bone	57	29	58	21
BASIC SLAG MEAL.	59	26	60	24
Floats	61	17	62	18
Redondite (raw)	63	11	64	8
Redondite (roasted) ..	65	22	66	9
No phosphate	67	15	68	6
Double superphosphate	69	29	70	12

AGRICULTURAL AVAILABILITY

TABLE SHOWING THE YIELDS OF HUBBARD SQUASH (POUNDS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black..	51	122	52	63
Dissolved bone	53	113	54	99
Acid phosphate	55	82	56	11
Fine ground bone	57	130	58	50
BASIC SLAG MEAL.	59	114	60	69
Floats	61	16	62	2
Redondite (raw)	63	0	64	0
Redondite (roasted) ..	65	36	66	0
No phosphate	67	0	68	0
Double superphosphate	69	107	70	13

TABLE SHOWING THE YIELDS OF BUDLONG TURNIP.

(Ruta baga or Swedish Turnip.)

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black ..	51	256	52	119
Dissolved bone	53	312	54	175
Acid phosphate	55	270	56	107
Fine ground bone	57	341	58	245
BASIC SLAG MEAL.	59	293	60	232
Floats	61	110	62	58
Redondite (raw)	63	1	64	0
Redondite (roasted) ..	65	117	66	1
No phosphate	67	16	68	1
Double superphosphate	69	245	70	89

AGRICULTURAL AVAILABILITY

TABLE SHOWING THE YIELDS OF ROOTS OF PURPLE-TOP STRAP LEAF-TURNIP (POUNDS).

Kind of Phosphate.	Plat No.	Limed.		Plat No.	Unlimed.	
		Tops.	Roots.		Tops.	Roots.
Dissolved bone-black ..	51	100	83	52	62	34
Dissolved bone	53	117	127	54	94	70
Acid phosphate	55	119	112	56	65	39
Fine ground bone	57	129	135	58	90	75
BASIC SLAG MEAL.	59	104	86	60	91	64
Floats	61	61	41	62	11	7
Redondite (raw)	63	14	9	64	0	0
Redondite (roasted) ..	65	46	39	66	3	1
No phosphate	67	9	5	68	0	0
Double superphosphate	69	107	113	70	42	23

TABLE SHOWING THE YIELDS OF BARLEY (WHOLE PLANT) IN POUNDS.

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black ..	51	11	52	1
Dissolved bone	53	10	54	2
Acid phosphate	55	10	56	1
Fine ground bone	57	14	58	5
BASIC SLAG MEAL.	59	16	60	9
Floats	61	15	62	1
Redondite (raw)	63	10	64	0
Redondite (roasted) ..	65	15	66	0
No phosphate	67	8	68	0
Double superphosphate	69	8	70	0

AGRICULTURAL AVAILABILITY

TABLE SHOWING THE YIELDS, IN POUNDS, OF TRIMMED HEADS OF CABBAGE.

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	289	52	41
Dissolved bone	53	422	54	168
Acid phosphate	55	308	56	29
Fine ground bone	57	421	58	135
BASIC SLAG MEAL.	59	396	60	165
Floats	61	78	62	0
Redondite (raw)	63	2	64	0
Redondite (roasted) . .	65	38	66	0
No phosphate	67	1	68	0
Double superphosphate	69	272	70	20

TABLE SHOWING THE YIELDS OF CRIMSON CLOVER (POUNDS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black .	51	158	52	55
Dissolved bone	53	161	54	116
Acid phosphate	55	151	56	130
Fine ground bone	57	157	58	130
BASIC SLAG MEAL.	59	142	60	152
Floats	61	118	62	98
Redondite (raw)	63	52	64	52
Redondite (roasted) . .	65	135	66	54
No phosphate	67	68	68	34
Double superphosphate	69	138	70	61

AGRICULTURAL AVAILABILITY

TABLE SHOWING THE YIELDS, IN POUNDS, OF NORBITON GIANT BEET (MANGEL WURZEL).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	328	52	3
Dissolved bone	53	380	54	101
Acid phosphate	55	340	56	8
Fine ground bone	57	447	58	16
BASIC SLAG MEAL.	59	362	60	73
Floats	61	223	62	0
Redondite (raw)	63	36	64	0
Redondite (roasted) . .	65	153	66	0
No phosphate	67	40	68	0
Double superphosphate	69	145	70	1

TABLE SHOWING THE WEIGHTS OF OATS (POUNDS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	138	52	124
Dissolved bone	53	167	54	156
Acid phosphate	55	161	56	158
Fine ground bone	57	173	58	161
BASIC SLAG MEAL.	59	165	60	161
Floats	61	147	62	117
Redondite (raw)	63	105	64	77
Redondite (roasted) . .	65	153	66	70
No phosphate	67	96	68	36
Double superphosphate	69	153	70	64

AGRICULTURAL AVAILABILITY

TABLE SHOWING THE YIELDS OF GERMAN GOLDEN MILLET CUT AND WEIGHED GREEN (POUNDS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	162	52	143
Dissolved bone	53	177	54	144
Acid Phosphate	55	139	56	149
Fine ground bone	57	165	58	153
BASIC SLAG MEAL.	59	148	60	141
Floats	61	163	62	146
Redondite (raw)	63	132	64	109
Redondite (roasted) . .	65	159	66	118
No phosphate	67	123	68	50
Double superphosphate	69	160	70	82

TABLE SHOWING THE YIELDS OF GREEN TOMATOES AND VINES (POUNDS).

Kind of Phosphate.	Plat No.	Limed.		Plat No.	Unlimed.	
		Vines	Fruit		Vines	Fruit
Dissolved bone-black . .	51	74	49	52	14	9
Dissolved bone	53	88	66	54	36	22
Acid phosphate	55	21	10	56	32	23
Fine ground bone	57	43	15	58	38	14
BASIC SLAG MEAL.	59	57	31	60	25	15
Floats	61	15	6	62	1	0
Redondite (raw)	63	5	2	64	1	0
Redondite (roasted) . .	65	16	7	66	5	1
No phosphate	67	8	1	68	4	0
Double superphosphate	69	46	18	70	3	0

AGRICULTURAL AVAILABILITY

TABLE SHOWING THE YIELDS OF ICEBERG LETTUCE (POUNDS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	26	52	7
Dissolved bone	53	41	54	17
Acid phosphate	55	25	56	6
Fine ground meal	57	32	58	8
BASIC SLAG MEAL.	59	42	60	8
Floats	61	12	62	1
Redondite (raw)	63	4	64	0
Redondite (roasted) . .	65	10	66	0
No phosphate	67	4	68	0
Double superphosphate	69	20	70	0

TABLE SHOWING THE YIELDS OF NEW ZEALAND SPINACH (POUNDS).

Kind of Phosphate.	Plat No.	Limed.	Plat No.	Unlimed.
Dissolved bone-black . .	51	15	52	14
Dissolved bone	53	47	54	19
Acid Phosphate	55	39	56	17
Fine ground bone	57	42	58	34
BASIC SLAG MEAL.	59	51	60	24
Floats	61	14	62	1
Redondite (raw)	63	7	64	0
Redondite (roasted) . .	65	18	66	0
No phosphate	67	8	68	0
Double superphosphate	69	59	70	0

AGRICULTURAL AVAILABILITY

In commenting on many of the above tables, Wheeler draws special attention to the fact that the extra-Nitrogen carried into the soil by the dissolved bone and fine ground bone appears possibly to have played an important part in determining the size of the crop. With a reasonable allowance for this, the high availability of the THOMAS PHOSPHATE POWDER is very striking. The above experiments were conducted on a basis of equal amounts of Phosphoric Acid used.

Experiments at the **Massachusetts Experiment Station** at Amherst, Mass., have confirmed the high availability of THOMAS PHOSPHATE POWDER as a source of Phosphoric Acid.

The **Fifteenth Annual Report of the Hatch Experiment Station, for January, 1903,** reports on an availability test of various phosphates, as per table given below. All plots have been manured alike with materials furnishing Nitrogen and Potash in available forms, and in equal amounts, Nitrogen being supplied at the rate of 52 lbs. per acre, and Potash at the rate of 152 lbs. of Actual Potash K_2O per acre. All phosphates used were supplied in quantities sufficient to furnish **phosphorus pentoxide** at the rate of **96 lbs. per acre.**

ONIONS ON PLOTS WITH EQUAL AMOUNTS OF PHOSPHORIC ACID.

Plots.	Fertilizer.	Onions (Bushels per Acre).	Scallions (Pounds per Acre).
1.	No phosphate	195.7	8,560
2.	Apatite	101.7	8,480
3.	South Carolina rock phosphate	121.8	9,360
4.	Florida soft phosphate	52.3	6,880
5.	Phosphatic Slag	252.0	5,600
6.	Tennessee phosphate	44.6	6,960
7.	No phosphate	50.5	5,360
8.	Dissolved bone-black	173.8	5,640
9.	Raw bone	301.4	4,144
10.	Dissolved bone meal	388.9	5,400
11.	Steamed bone meal..	243.8	5,840
12.	Acid phosphate	159.4	6,560
13.	No phosphate	26.2	6,600

AGRICULTURAL AVAILABILITY

Commenting on this report Prof. Brooks says:

> "The phosphatic slag has apparently furnished Phosphoric Acid in an exceedingly available form, the yield on the plot receiving the slag being almost equal to that on the dissolved bone-black."*

The **Sixteenth Annual Report of the Hatch Experiment Station for January, 1904,** reports on 13 plots as indicated in table given below. All plots were supplied with materials furnishing Nitrogen and Potash in available forms, and in liberal amounts, the same quantities being applied to each. Nitrogen was furnished at the rate of 52 lbs. per acre, and Potash at the rate of 152 lbs. of Actual K_2O per acre. All phosphates used in the comparison were used in quantities sufficient to furnish 96 lbs. of phosphorus pentoxide per acre.

CABBAGES ON PLOTS WITH EQUAL AMOUNTS OF PHOSPHORIC ACID.

Plots.	Fertilizers used.	Number of Hard Heads.	Hard Heads (Lbs.)	Soft Heads, Leaves and Stumps (Lbs.)	Total Crop (Lbs.)
1.	No phosphate	1,184	4,040	9,360	13,400
2.	Apatite	776	3,560	17,360	20,920
3.	South Carolina rock phosphate	2,928	12,040	24,480	36,520
4.	Florida soft phosphate	816	3,840	21,840	25,680
5.	Phosphatic Slag	2,232	9,920	28,040	37,960
6.	Tennessee phosphate	440	1,720	29,160	30,880
7.	No phosphate	104	400	14,120	14,520
8.	Dissolved bone-black	2,336	8,392	31,520	39,912
9.	Raw bone	2,304	11,800	32,440	44,240
10.	Dissolved bone meal	2,384	12,760	29,320	42,080
11.	Steamed bone meal	1,632	8,720	28,200	36,920
12.	Acid phosphate	1,296	6,200	24,120	30,320
13.	No phosphate	120	440	8,080	8,520

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* Fifteenth Annual Report of the Hatch Experiment Station, Massachusetts Agricultural College, January, 1903, Page 127, ¶1.

AGRICULTURAL AVAILABILITY

Commenting on this test Prof. Brooks remarks:

> "The phosphatic slag ranks among the best of the phosphates used. It is exceeded in yield of hard heads by the dissolved bone-black, the South Carolina rock and the raw bone, in the order named; while in total weight of crop it is exceeded by the dissolved bone, the raw bone and the dissolved bone-black."*

At the **Ohio Experiment Station** a long series of experiments with various phosphates has been carefully conducted, as a result of which Director Thorne, in **Bulletin 100**, speaks of THOMAS PHOSPHATE POWDER as follows:

> "The experiments made at this Station indicate that the total phosphoric acid of BASIC SLAG is practically as effective as the available phosphoric acid of acid phosphate."

In **Bulletin 110, pages 65-67,** the following summary tables give the value of increase from different sources of Phosphoric Acid:

VALUE OF AVERAGE INCREASE FROM DIFFERENT SOURCES OF PHOSPHORIC ACID.

Carriers of Phosphoric Acid.

Crops	Culture	No. of crops grown	Acid Phosphate		Raw bone meal		Dissolved bone black		Basic Slag	
			Average Value of Increase	Rank	Average Value of Increase	Rank	Average Value of Increase	Rank	Average Value of Increase	Rank
Corn......	5-year rotations	9	$3.23	3	$2.30	4	$3.35	2	$3.36	1
Oats......	5-year rotations	10	3.77	2	3.71	3	4.37	1	3.71	3
Wheat....	Both rotations	17	8.24	4	8.71	2	8.68	3	9.87	1
Hay......	Both rotations	17	1.29	4	1.91	3	1.92	2	2.70	1

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* Sixteenth Annual Report of the Hatch Experiment Station, Massachusetts Agricultural College, January, 1904, Page 137, ¶4.

AGRICULTURAL AVAILABILITY

"By consolidating the values given in the above table and regarding it as representing the probable outcome of an average rotation in which the four crops have followed each other as in the actual rotation, then the value of the total increase per acre due to the various sources of phosphoric acid, when supplemented with uniform amounts of nitrogen and potash, will be represented by the following figures":

	Per Acre.
Value of increase from BASIC SLAG	$19.14
Value of increase from dissolved bone black.....	18.32
Value of increase from raw bone meal	16.63
Value of increase from acid phosphate	16.53

Taking BASIC SLAG PHOSPHATE as 100, we find the following as the proportionate values of these materials as sources of phosphoric acid:

BASIC SLAG PHOSPHATE	100
Dissolved bone-black	96
Raw bone meal	87
Acid Phosphate	87

"While these results are very close together in some cases, and more work will be necessary to determine their relative value, yet there seems to be no doubt that most crops have ability to utilize phosphoric acid that is insoluble in water to a larger extent than is commonly recognized."*

Bulletin No. 68, of the **Maryland Experiment Station,** includes reports on an elaborate series of experiments with different phosphates. In these experiments (which cover three corn crops, one wheat crop, and one hay crop), the average production of three soluble phosphoric acid plots was as follows:

Grain	11,298 lbs. per acre
Fodder	15,618 " " "
Total	26,916 lbs. per acre

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*Bulletin 110 Ohio Station.

AGRICULTURAL AVAILABILITY

The average of three THOMAS PHOSPHATE POWDER (Basic Slag) plots was as follows:

Grain	11,795 lbs. per acre
Fodder	16,059 " " "
Total	27,854 lbs. per acre

In the summary of this Bulletin **Director Patterson** says:

"Slag Phosphate produced a greater total yield and at less cost than the average of the soluble phosphoric acid plots and the bone meal plots."

Bulletin No. 83, of the **Florida Experiment Station,** reports an elaborate series of tests on pine-apples, including over 96 plots with 100 plants in each plot. This Bulletin reports:

> "The plot giving the largest total returns, for the summer crop of 1903, was plot No. 35, Section 1, fertilized with BASIC SLAG, Dried Blood and High Grade Sulphate of Potash. This plot yielded at the rate of 537½ crates per acre; valued at $869.37½."

In this connection the following from **Bulletin 83,** of the **Florida Station,** should prove of interest:

> "It's not an easy matter to say why the Acid Phosphate has an injurious effect upon pine-apples. . . . The most satisfactory explanation we can offer is that ordinary Acid Phosphate contains Sulphates of iron with aluminum and it is really the presence of these astringent salts which causes the injury . . . It is perhaps well to caution against the use of Dissolved Bone-Black in as much as in many cases High Grade Acid Phosphate, colored with charcoal (or lamp black), is on the market in imitation of the Dissolved Bone-Black. It is well for one not experienced in the chemistry of fertilizers to 'use no form of acid phosphate whatever for pine-apples,' but to rely upon Bone Meal or Slag."

The **North Carolina Experiment Station** determines only the Total Phosphoric Acid in the THOMAS PHOSPHATE POWDER, and values it all at 3½c. per lb. (see vol. 29, Bulletin, N. C. Dept. Agr.).

It would be possible to continue the evidences of the high availability of the Phosphoric Acid in the THOMAS PHOSPHATE POWDER almost indefinitely; but the above specific instances serve to point out that high degree of actual availability to plants, which is now generally conceded by all careful investigators.

AMMONIUM CITRATE METHOD NOT APPLICABLE.

The present Official Method, which employs a neutral solution of Ammonium Citrate as a solvent for phosphoric acid compounds not water soluble, shows a much lower amount of Available Phosphoric Acid in the THOMAS PHOSPHATE POWDER than the field tests have repeatedly shown is available to growing crops. The THOMAS PHOSPHATE POWDER contains a considerable amount of free lime, which very materially affects the solvent action of the Ammonium Citrate solution. Wiley says:

> "Experience has shown that the manurial value of basic slags does not depend alone on their content of phosphoric acid. Slags may contain **tri**—as well as **tetracalcium phosphate**, and even this latter salt may exist in states of differing availability. In determining the availability of basic slag for manurial purposes its solubility in ammonium citrate is considered the best standard. But this solubility will evidently be influenced by the basicity of the sample, or in other words, by the quantity of lime present. A slag rich in calcium oxide would deport itself differently with a given ammonium citrate solution from one in which the lime had been chiefly converted into carbonate."*

* Wiley's Principles and Practice of Agricultural Analysis, Vol. II, Page 77, ¶80.

The effect of the lime present is to make the neutral solution of Ammonium Citrate alkaline, thus diminishing the solvent action of the solution.

The effect of the slight acidity, or slight alkalinity of the Ammonium Citrate solution, is clearly shown in the table given on page **137 of Wiley's "Principles and Practice of Agricultural Analysis" Vol. II,** which table it is not necessary to reproduce here, as these effects are generally recognized by all agricultural chemists.

In the **Connecticut State Experiment Station Bulletin for 1906**, **Jenkins** sums up the matter very clearly as follows:

> "It needs to be remembered that **'available phosphoric acid'** is purely a trade name for the sum of the water-soluble and citrate-soluble phosphoric acid, and has no necessary connection with the availability of the phosphoric acid to the crops. . . . The method of citrate extraction was advised for, and is strictly applicable only to, the determination of that part of the phosphoric acid in a plain superphosphate (Acid Phosphate or Dissolved Rock Phosphate), which had been at first dissolved by sulphuric acid, but by further chemical reactions, has become insoluble in water."

Correspondence with practically all of the Experiment Stations in the country has brought out the fact that nearly every Station regards the Ammonium Citrate Method as unsuited for use upon the THOMAS PHOSPHATE POWDER. At the California Station no attempt is made to use the Ammonium Citrate Method upon the Thomas Phosphate, the availability of the Phosphoric Acid being determined entirely according to the fineness of the material.

Jordan, of the New York Station, says:

> "It is conceded that the available method is not applicable to the analysis of Thomas Phosphate Powder for available phosphoric acid."†

† May 28, 1908.

Haskins, of the Massachusetts Station, advises that the Ammonium Citrate Method is not there employed without first neutralizing the lime in the THOMAS PHOSPHATE POWDER with citric acid. At the **Pennsylvania Station** no attempt is made to determine the availability, the Station Report simply stating that no Official Method for determining the available phosphoric acid in the material exists in this country.

The same degree of uncertainty or lack of uniformity in the treatment of this material, prevails throughout the country.

ACTION BY THE ASSOCIATION OF OFFICIAL AGRICULTURAL EXPERIMENT STATION CHEMISTS.

The matter has frequently been brought to the attention of the Association, but definite action in regard to the adoption of a method has been postponed from year to year. Committees appointed to investigate methods have at various times reported lack of time for suitable investigations, and the former limited consumption of the material itself in this country doubtless delayed action. In 1899 the Committee reported that of all methods tested, Wagner's Method gave the most concordant results; but no method was adopted at that time. The appointment of subsequent committees led to no definite action being taken. At the Annual Meeting of the Association in 1905, the writer personally brought this matter before the Association, at which time a committee was appointed to investigate the matter. The desirability of the adoption of a suitable method was urged upon the Association by A. G. Stillwell at the Meeting of the Association in 1906, and was emphasized by Haskins at the Meeting in 1907. The Association has at all times appreciated the desirability of a suitable method, and at the Meeting of the Association in 1907, the following recommendations in regard to THOMAS PHOSPHATE POWDER, or Basic Slag Phosphate, were adopted:

III. PHOSPHORIC ACID.

It is recommended—

(1) That Thomas or basic slag be prepared for analysis as are other fertilizers or fertilizing materials under the methods of this association.

Adopted provisionally pending further work.

(2) That the solution for analysis be made according to (a_7), page 2, Bulletin 107, under "(2) Total phosphoric acid," or in strong hydrochloric acid alone. In the latter case, after the portion for analysis is measured out, add nitric acid and heat for a few minutes. Then determine total phosphoric acid according to the official methods.

Adopted provisionally pending further work.

(3) That the fineness of the material be determined according to the plan followed with bone meal and the commercial value estimated on the basis of total phosphoric acid and fineness of product.

Adopted provisionally pending further work.

(4) That the referee further study the subject of basic slag with a view to devising some method for the determination of the available phosphoric acid which it contains.

This recommendation was made by Committee A and was adopted.*

It should be noticed, however, that the above concerns only the **valuation** of the material, and not its **analysis.** Further, the plan for valuation according to fineness makes no account of the possibility of adulteration of the THOMAS PHOSPHATE POWDER, or of the fact that some Basic Slags possess a higher degree of availability than others of the same degree of fineness.

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* U. S. Department of Agriculture, Bureau of Chemistry, Circular No. 38, Page 2, ¶3.

OBJECTIONS TO FINENESS METHOD.

As already intimated, any method for the estimation of the availability of the Phosphoric Acid in THOMAS PHOSPHATE POWDER (Basic Slag Phosphate), based upon the fineness of the material, would very possibly permit of the adulteration of the Thomas Phosphate with very finely ground raw phosphate rock. Unscrupulous manufacturers or dealers might thus foist upon farmers a so-called "Phosphate Powder" or "Basic Slag Phosphate" which might possess a high Total Phosphoric Acid and the requisite degree of fineness and yet be comparatively unavailable. In this connection the desirability for a chemical method is very apparent. Wiley says:

> "It is well known that the tetrabasic phosphate in slags is completely soluble in Citric Acid, while the tribasic phosphate is only slightly, if at all, attacked."*

Nor would any method based upon the fineness of the material discriminate between genuine THOMAS PHOSPHATE POWDER (Basic Slag Phosphate), and so-called Basic Phosphate Powders which are manufactured by certain processes, the products of which are not at present well understood. Two processes, one known as "Method of Making Basic Slag" covered by Letters Patent No. 714,330, Nov. 25, 1902, and the other known as "Phosphate and Method of Making Same" covered by Letters Patent No. 714,331, Nov. 25, 1902, exist in this country. The first process consists briefly in mixing about 85% of tri-calcium phosphate with about 5% of oxide manganese, and about 10% of oxide of iron, and subjecting the mixture to a high oxidizing flame in a cupola furnace until fusion takes place, the resultant material being ground up after cooling and known as Basic Slag Phosphate. The second consists in mixing tri-calcium phosphate with ordinary waste slags, (such as open-hearth slag) that contain no phosphoric acid, fusing the same and grinding after cooling.

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* Wiley's Principles and Practice of Agricultural Analysis, Page 82, ¶3, Vol. II.

European chemists recognize the fact that the Phosphoric Acid in slags treated with silica in the converter, have a much higher degree of availability than have slags treated with fluorspar in the converter; yet a method based upon fineness alone would make no recognition of this fact.

Basic slags also may have a widely divergent composition. Wiley says:—

> "When a basic slag is made with lime free from phosphoric acid, nearly the whole of the phosphoric acid is combined as tetrabasic calcium phosphate. On the other hand, when the lime employed contains some of the ordinary mineral phosphate the basic slag produced becomes a mixture of this mineral phosphate with tetracalcium salt. The mineral phosphate is probably not rendered any more available than it was before."*

The fact thus clearly brought out points strongly to the necessity for a chemical method that shall prevent the sale of adulterated slags manufactured by processes such as those covered by the patents referred to above.

THE DESIRABILITY OF WAGNER'S METHOD.

In all probability, Wagner, of the Darmstadt Station, has done more work upon THOMAS PHOSPHATE POWDER and other basic phosphatic slags, than any other chemist in the world, and his long experience and repeated tests make any method used and recommended by him worthy of a special consideration. Wagner's Method is now in general use in England and on the Continent of Europe, and it would seem to be highly preferable to any other method for adoption by the Association of American Agricultural Experiment Station Chemists. In this connection the following letter from Dr. Harvey W. Wiley to Mr. M. Dietsch, of the Thomasphosphatfabriken, is of interest:

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* Wiley's Principles and Practice of Agricultural Analysis, Page 72, ¶70, Vol. II.

United States Dept. of Agriculture,
Division of Chemistry,
Washington, D. C.

H. W. Wiley, Chief,
E. E. Ewell, First Assistant,
W. D. Bigelow, Second Assistant.

April 13, 1900.

Mr. M. Dietch;
Verein deutsch-oesterr, Thomasphatfabriken,
Hafenplatz, 4, Berlin, S. W., Germany.

Dear Sir:

The proper method of analysis of the Thomas phosphate powders has been considered very carefully in this country by the Division of Chemistry of Agriculture and by the Association of Official Agricultural Chemists. Various methods of analysis have been tried very thoroughly. At the last meeting of the Association of Official Agricultural Chemists, held in San Francisco in July, 1899, the referee on phosphoric acid, as a result of the experiments which had been tried, made the following statement on page 68 of bulletin No. 57 of this division, a copy of which I send you under separate cover: "Of the many methods and solvents used in these trials Wagner's method seems to be the only one that will give uniformly concordant results."

In the second volume of my work; "The Principles and Practice of Agricultural Analysis," on page 74 and the following are given the various methods practiced for the analysis of this material. In these, the method of Wagner is given the preference, only one objection being urged to it, namely, the failure to specify the temperature at which digestion with the reagents is to be carried on.

You will see from the above that Wagner's method is the only one which has any standing in this country, in the estimation of basic phosphatic slags such as the Thomas phosphate powder.

The method referred to has not been adopted officially by our association simply because there is practically no commerce in such goods in this country. Should occasion arise for official control in this country, there would be no doubt of the adoption of the Wagner method in all of its essential points, as the official method for the United States.

Very truly yours,

(Signed) H. W. Wiley,
Chemist.

It should be noted that the only possible objection that Dr. Wiley had at that time to the Wagner Method was the failure to specify the exact temperature at which the operation should be conducted. Wagner's Method, as at present used by him at the Darmstadt Station (given in full in this pamphlet) overcomes this objection, and stipulates that the digestion is to be conducted at a temperature of 17½° C. The solvent employed in Wagner's Method is a 2% solution of Citric Acid, and attention should again be called to Wiley's remark that "the tetrabasic phosphate in slags is completely soluble in Citric Acid, while the tribasic phosphate is only slightly, if at all attacked."

WAGNER'S METHOD IN FULL.*

DETERMINATION OF "AVAILABLE" PHOSPHORIC ACID IN BASIC SLAG BY MEANS OF THE 2% SOLUTION OF CITRIC ACID, AS PER WAGNER'S METHOD.

I. Preparation of Samples for Analysis.

Pass the sample of Basic Slag to be analyzed through a 2 mm. sieve, in order to separate the coarse particles. During this operation care should be taken that none of the fine dust escapes. To this end the sieve employed should have a closely fitting cover, and bottom.

* As used at the Darmstadt Station.

Slightly crush the residue, if any, and further sieve. Exclude from analysis any residue there may be of second sieving, but weigh it, and take it into calculation as free from soluble phosphoric acid.

Thoroughly mix all the powder which has passed through the sieve, taking care to avoid escape of dust.

II. Method of Analysis.

(A) Making the Citric Solution.

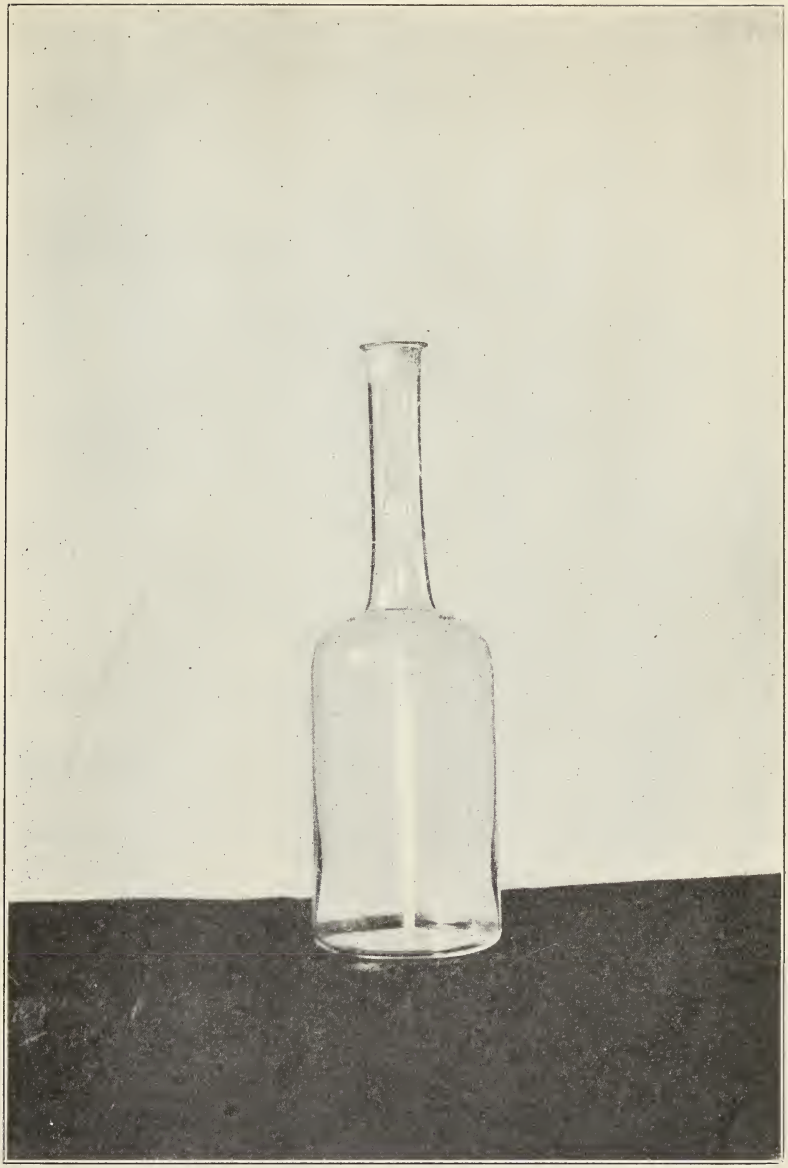
Weigh 5 grams of the Basic Slag sieved as above; transfer to a ½-litre flask containing 5 ccm. of Alcohol, and make up to the mark with dilute Citric Acid solution (2%) of a temperature of 17½°C. Fit the flask with a rubber stopper, and put at once into the rotary apparatus (see illustration page 2) for thirty minutes, making thirty to forty revolutions per minute. Take off and filter immediately.

(B) Analysis of the Citric Solution.

Either of the two following methods give exact results:

(1) Molybdate Method.

Take 50 ccm. of the clear filtrate and add to it 100 ccm. of Molybdate solution (see solution 3, page 34). Put the beaker into a water bath until the temperature reaches 65°C.; take out and allow to cool at ordinary temperature. Then filter, and wash the yellow precipitate of Phospho-Molybdate of Ammonia with 1% Nitric Acid. Now dissolve in 100 ccm. of 2% Ammonia (cold) and add to the solution 15 ccm. of Magnesia Mixture (see solution 4, page 34), drop by drop during continuous stirring; then cover the beaker with a glass cover and allow to stand for about two hours. Then filter the double Phosphate of Ammonia and Magnesia through a filter of known ash-contents; wash with 2% Ammonia and put on to dry. Brush precipitate off paper, and burn the paper until reduced to ashes; add the precipitate to the ash, burn on Bunsen burner, and finally still further glow in Rossler's stove for two minutes. Take out and allow to cool in the desiccator and then weigh.



Flask, 500 c. c. capacity, used in analysis of Basic Phosphatic Slags according to Wagner's method.

(2) Citrate of Ammonia—Magnesia Mixture Method.

Put 100 ccm. of the clear filtrate into a 200 ccm. flask and add 50 ccm. of Citrate Magnesia mixture (see solution 5, page 35). Heat the flask slightly (about 15 minutes) by means of a Bunsen burner until the Silicic Acid has been precipitated. Shake the flask in order to conglomerate the precipitate, and continue heating to boiling point. Allow to cool, add 25 ccm. of Hydrochloric Acid of 1.124 S.G., and allow it to stand for about 30 minutes, during which time shake occasionally. Fill up the mark with water, fit the flask with a rubber stopper, and shake vigorously several times till the precipitate of Silicic Acid has been divided into very fine particles. Then filter and add to 100 ccm. of the filtrate (=0.5g Basic Slag) 50 ccm. of Ammonia (10%) while stirring the contents of the beaker. Continue stirring, preferably by means of a stirring apparatus, for 30 minutes, filter the precipitate, and treat as customary.

III. Preparation of Solutions.

(1) Concentrated Solution of Citric Acid (10%).

Dissolve in water exactly 1 kilo of chemically pure crystallized Citric Acid having its full percentage of water of crystallization. Make up this solution exactly to 10 litres and add 5 grams of Salicylic Acid.

(2) Dilute Solution of Citric Acid (2%).

Mix exactly 1 volume of Concentrated Solution of Citric Acid (solution No. 1) with four volumes of water.

(3) Molybdate Solution.

This may be prepared after either of the following methods:

(a) Put 125 grams. of Molybdenic Acid into a 1-litre flask with about 100 ccm. of water and dissolve by adding, while shaking, about 300 ccm. of 8% Ammonia. Mix this solution with 400 grams of Nitrate of Ammonia, filled up to the mark with water, and add the whole to 1 litre of Nitric Acid of 1.19 S.G. Allow to stand for 24 hours at a temperature of 35° Celsius, and then filter.

(b) Place 150 grams of Molybdate of Ammonia into a 1-litre flask and dissolve by about 500 ccm. of water. Pour this solution into 1 litre of Nitric Acid of 1.19 S.G., add 400 grams of Nitrate of Ammonia, and bring the whole up to 2 litres by adding water. Allow to stand for 24 hours at a temperature of 35° C., and then filter.

(4) Magnesia Mixture.

Dissolve 110 grams of pure crystallized Muriate of Magnesia and 140 grams of Muriate of Ammonia in 1300 ccm. of water, and mix this solution with 700 ccm. of Liquor of Ammonia containing 8% of Ammonia. Allow this mixture to stand several days, and then filter.

(5) Citrate of Ammonia—Magnesia Mixture.

Put 200 grams of Citric Acid and 40 grams of Muriate of Ammonia into a 1-litre flask, and add 200 ccm. of water, and further 500 ccm. of Liquor of Ammonia (20%.) Keep the flask stoppered until the contents are dissolved and cooled down. Then add 55 grams of Muriate of Magnesia, and fill up to the mark with water.

IV. Precautions to be taken in determining the Citric Soluble Phosphoric Acid in Basic Slag.

(1) It is very necessary that the solution of Citric Acid used for the analysis of Basic Slag should contain in 1 litre exactly 20 grams of chemically pure crystallized Citric Acid having its full percentage of water of crystallization.

(2) Where a large number of analyses are made it is convenient to prepare the concentrate solution of Citric Acid, 10% (solution 1), but in this case the concentrated solution must have 5 grams of Salicylic Acid added to it in order to preserve it.

(3) The solution of Citric Acid to be used must be as nearly as possible of medium room-temperature (17½°C. i. e. 14°R.) as variations from this temperature give rise to error. The Rotary apparatus must therefore be used in a room of approximately this temperature.

(4) It will sometimes be seen, when pouring the 500 ccm. of the Citric Acid solution on to the 5 grams of Basic Slag, that the latter clogs somewhat, and becomes permeated only after considerable time. In order to guard against this, 5 ccm. of Alcohol are poured into the ½-litre flask before the Basic Slag is put in; this ensures immediate and complete permeation.

(5) The Rotary apparatus prescribed for shaking the flasks must not be substituted by ordinary shaking or rocker apparatus, as the latter differ in construction and effect.

(6) The ½-litre flasks (after the design of Professor Wagner) must have a neck-width of at least 20 mm., and are marked at least 8 cm. below the mouth. These two points are important, for, if the neck-width is too narrow and the mark too high, the result will be too low, owing to the movement of the liquid being so limited.*

(7) The Rotary apparatus must turn around its axle 30 to 40 times per minute. Variation within these limits has no marked influence on the results.

(8) The filtration must be done immediately after 30 minutes rotation, and it is recommended to use a folded filter paper of such size that the whole quantity of liquid can be poured on to the filter at once. Small and bad filtering papers give rise to error, in consequence of too slow filtration. If at first the filtrate is not clear, it must again be filtered (through the same filter) until it becomes clear.

(9) If the beaker containing the mixture of Phosphatic and Molybdenic solutions is put into the water-bath until the temperature reaches between 60 and 70°C., a precipitate free from Silicic Acid results. If heating is continued for a considerably longer time, the precipitate will often be mixed with Silicic Acid, especially when the Molybdenic solution is not added to the filtrate immediately but only after 6 or 12 hours (or longer) after filtration. If Silicic Acid is present, the precipitate dissolves slowly in Ammonia, but at first not clearly. Special attention must be paid to the point that the yellow precipitate

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* See illustration page 33.

is dissolved quickly and quite clearly by Ammonia (2%) not made warm. If the solution becomes clear only after some time, Molybdenic solution and Nitric Acid must be added to same, in order to get a pure precipitate of Phospho-Molybdate of Ammonia.

RESULTS OF ANALYSES OF THOMAS PHOSPHATE POWDER (Basic Slags) BY WAGNER'S METHOD.

The following analyses of Basic Phosphatic Slags by Prof. Wagner, of the Darmstadt Station, have been reported to the writer on the original Darmstadt analysis certificates, and are interesting as showing the amounts of Phosphoric Acid reported as Available in these Slags, together with the Total Phosphoric Acid found in the same. The fineness is also reported. The fineness at the Darmstadt Station is reported according to the Standard Sieve, Amadeus Kahl of Hamburg.*

	Total Phos. Acid.	Available Phos. Acid.	Fineness.
1.	17.15	15.62	77
2.	17.43	16.03	78
3.	18.08	15.74	77
4.	18.24	15.73	76
5.	18.03	16.35	79
6.	19.37	15.84	77
7.	18.47	16.72	84
8.	18.12	15.91	82
9.	18.11	16.27	81
10.	19.77	16.95	78
11.	18.76	15.82	80
12.	19.46	16.82	86
13.	19.54	16.13	69
14.	18.66	16.43	79
15.	18.84	15.89	81

Haskins, of the Massachusetts Station at Amherst, Mass., reports as follows on samples of THOMAS PHOSPHATE POWDER (Basic Slag Phosphate), taken in the open market and analyzed by him:

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* Apertures 0.17 m. m.

First treating the Slag with a solution of Citric Acid to neutralize the free lime, then digesting with the neutral Ammonium Citrate solution at 65° C., and proceeding in the usual manner.

Sample No.	Total Phos. Acid	Reverted (Avail.) Phos. Acid	Insoluble Phos. Acid
23-31	17.45	6.95	10.50
85-383	17.96	8.37	9.59

Haskins also reports that he analyzed all of the above samples according to Wagner's Method with the following results:

Sample No.	Available Phos. Acid
23	15.24%
31	15.52
85	15.78
383	15.40

In regard to the valuation of these same samples Haskins reports the valuation by mechanical analysis to be as follows:

Sample Nos. 23-31	$13.60 per ton.
" " 85-383	14.02 " "

In arriving at this valuation, such proportional part of the Total Phosphoric Acid as is represented by the proportion of the material that will pass through a sieve having 50 meshes to the linear inch, is valued at 4 cents per pound, and the balance of the Total Phosphoric Acid is valued at 3 cents per pound. In valuing the same lots of THOMAS PHOSPHATE POWDER, and considering the Phosphoric Acid reported as Available according to Wagner's Method as being worth 4½ cents per pound (as it would be if soluble in Ammonium Citrate), the writer finds that based on the above analyses by Haskins, the valuations are as follows:

Sample Nos. 23-31	$13.84 per ton,	as against $13.60 per ton, the valuation according to the mechanical analysis.
Sample Nos. 85-383	$14.03 per ton,	as against $14.02 per ton, according to the valuation by the mechanical analysis.

It is apparent, therefore, that on a genuine, or unadulterated, THOMAS PHOSPHATE POWDER (Basic Slag Phosphate), there is little probability of over-valuing the material according to Wagner's Method, and that by the adoption of Wagner's Method purchasers of this material are safeguarded against imposture and adulteration.

CONCLUSION.

Importers advise that the demand for THOMAS PHOSPHATE POWDER in this country is rapidly increasing, and that the advance call for this material for next season is more than double that of the season just past. To meet this condition of affairs it is incumbent upon the Association of Official Agricultural Chemists to agree upon some uniform Official Method of Analysis; as importers and dealers, and Experiment Station officials, are now put to a great deal of unnecessary trouble through the lack of such a method.

As is well known, many States require the guarantee of **"Available"** Phosphoric Acid, and the point is immediately raised, on what can a guarantee of "Available" Phosphoric Acid in THOMAS PHOSPHATE POWDER be based, and by what method shall the Experiment Station determine whether the guarantee is complied with or not? The action thus far taken by the Association concerns only the question of **valuation,** and fails to be of assistance in adjusting the matter of **availability.**

There seems to be no reason why Wagner's Method should not be adopted by the Association, thus relieving the present very unsatisfactory condition, and placing a valuable phosphate upon a proper footing.

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